Reprinted from "Bulletin of Marine Science" Volume 33, 1983, pp. 227-238, Manooch and Hogarth: Stomach contents and giant trematodes from wahoo, Acanthocybium solanderi, collected along the South Atlantic and Gulf coasts of the United States. With permission from Rosenstiel School of Marine and Atmospheric Science of the University of Miami.

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STOMACH CONTENTS AND GIANT TREMATODES FROM WAHOO, *ACANTHOCYBIUM SOLANDERI*, COLLECTED ALONG THE SOUTH ATLANTIC AND GULF COASTS OF THE UNITED STATES

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ABSTRACT

Stomachs of 885 wahoo, *Acanthocybium solanderi*, collected along the southeastern Atlantic and Gulf of Mexico coasts of the United States from 1965–1981 were examined for food contents and parasites. Approximately 53% of the stomachs contained food consisting primarily of pelagic fishes and squids. Frigate mackerel, *Auxis thazard*, porcupinefish, *Diodon hystrix*, and flyingfish, *Cypselurus* sp., occurred most frequently. There were only slight differences between the diets of wahoo collected from the Gulf of Mexico and from the southeastern United States. Unlike several sympatric species, wahoo did not eat small items, nor did they feed as readily at the surface. No relationship was found between the size of wahoo and the size of prey. Giant digenetic trematodes, tentatively identified as *Hirudinella ventricosa*, were found in 80.5% of the stomachs ($\bar{x} = 2$ parasites/fish). Size and sex of the host had no significant effect on parasitic infestation; geographical area of collection did.

The wahoo, *Acanthocybium solanderi* (Cuvier), is a large, pelagic gamefish inhabiting the tropical and subtropical waters of the Pacific, Indian, and Atlantic Oceans, as well as the Gulf of Mexico and the Caribbean. After World War II, the development of light and efficient fishing tackle and fast, offshore sportfishing boats gave many anglers a greater opportunity to catch pelagic gamefishes, previously available only to affluent sportsmen. Once the fighting capabilities and palatability of the wahoo became known, its popularity grew rapidly, and it is a highly regarded sportfish.

Along the coast of the southeastern United States the wahoo has become an important part of the trophy sport catch, but catches have been low because relatively few anglers fish for them compared with most other finfishes. In fact, a 1979 recreational fishery survey of the Atlantic and Gulf coasts did not even include the species (Marine Recreational Fishery Statistics Survey, 1980). Wahoo landed in the Southeast Region are mostly caught off the Florida Keys and off Oregon Inlet and Hatteras, North Carolina. Browder et al. (1981) reported that charter boat anglers in the Florida Keys spend about 67% of their fishing effort for bluewater pelagic species, including wahoo. Manooch and Laws (1979) and Manooch et al. (1981) estimated that North Carolina charter boat fishermen caught 3,062 wahoo weighing 76,324 pounds and 2,707 wahoo weighing 73,603 pounds in 1977 and 1978, respectively.

Requests for general information about this exciting fish have resulted in an increase in popular articles on sportfishing, but scientific information on its life history in the Atlantic is not available. The paucity of published scientific data results, in part, from the difficulties of obtaining adequate samples. Wahoo are difficult to sample because they inhabit an offshore environment, are caught primarily by hook and line, are seasonal to most ports, and are considered trophy fish by anglers who are reluctant to allow biologists to dissect their catch.

This study is directed at one component of the life history of wahoo, food habits, and is a composite of two research efforts: one undertaken by the junior author as part of his doctoral research at North Carolina State University from

1965 through 1972 (Hogarth, 1976) and the other, a regionwide predator-prey investigation conducted by the National Marine Fisheries Service, Southeast Fisheries Center laboratories in 1980 and 1981. The objectives are to identify foods found in the stomachs of wahoo, make a comparison between diets of fish collected along the southeastern United States and the Gulf of Mexico, relate the feeding behavior of wahoo with that of sympatric pelagic fishes, and evaluate the parasitic infection of wahoo by giant trematodes.

METHODS

Of the 885 wahoo stomachs examined for food and parasite studies, 666 were from fish landed at Oregon Inlet and Hatteras, North Carolina during the summer and fall of 1965–1972 and in the same seasons of 1980 and 1981. Additional samples were obtained from locations along the southeast Atlantic and Gulf of Mexico coasts and from Bimini (Table 1). Samplers throughout the region apportioned their efforts to coincide with local charter boat fishing activities, primarily April through November. Port samplers met boats at the docks as a day's catch was being unloaded. Most of the fishermen either wanted to have their fish saved whole for mounting or filleted and packed on ice or frozen upon returning to the dock. Field personnel obtained data only from the latter group in exchange for cleaning the fish or from fish cleaners who worked at local fish markets.

Fish were measured to the nearest millimeter (FL) and weighed to the nearest tenth of a kilogram. Stomachs and gonads were extracted, placed in labeled cloth bags or cheese cloth, and immediately submerged in 10% Formalin.

In the laboratory stomach contents were separated taxonomically and were enumerated giving the relative number of each food type in the stomachs. Frequency of occurrence of materials was determined by counting every stomach that contained at least one specimen or part of a specific item (taxon). Empty stomachs were not included. Volumes of foods were obtained for 1980–1981 specimens by water displacement and were later converted to weights by using a linear regression equation. Larval and juvenile food fishes were identified after they had been cleared and stained following the methods discussed by Dingerkus and Uhler (1977) and Taylor and Van Dyke[1]. When scombrid vertebrae occurred in the contents, they were identified by comparison with a reference collection of known vertebrae maintained in the North Carolina State University Ichthyology Laboratory. This procedure enabled us to more accurately identify closely related scombrids (e.g., *Auxis thazard* and *A. rochei*). Parasites were separated from the food items, counted, and identified. If a stomach contained only parasites, it was considered empty. All data were programmed on SAS format and analyzed as percent frequency of occurrence and percent of total number.

RESULTS

Stomach Contents

Of the 885 wahoo stomachs, 466 (52.6%) contained food items. Of those, fish occurred in 95.3% and accounted for 92% of the identified items (Table 2). Major families of fishes by percent frequency of occurrence and percent number of items were Scombridae 36.1% and 23%; Diodontidae 15.7% and 12.6%; Exocoetidae 11.4% and 6.5%; and Clupeidae 10.5% and 8.4%. Representative species of these, and other less frequently occurring families, belonged to either the fast-swimming pelagic fish community, e.g., round herring, *Etrumeus teres,* Atlantic flyingfish, *Cypselurus melanurus,* and frigate mackerel, *Auxis thazard,* or to families occasionally associated with *Sargassum,* e.g., juvenile carangids and balistids, butterfish, *Peprilus triacanthus,* and porcupinefish, *Diodon hystrix.* The latter tend to be more surface-associated.

Invertebrates were found only occasionally. Squid, *Loligo* sp., paper nautilus, *Argonauta argo,* and a raninid crab megalops were identified in 9.9, 0.6, and 0.2% of the stomachs, respectively. *Sargassum,* eelgrass, and a large, rectangular piece of black plastic were probably only eaten accidentally.

[1] Taylor, W. R. and G. C. Van Dyke. 1978. Unpublished manuscript. Staining and clearing small vertebrates for bone and cartilage study. Smithsonian Institution, Washington, D.C. 20560. 19 pp.

Table 1. Number of wahoo sampled and number containing food by area and year

Area	Year(s)	Number of Stomachs	Number of Stomachs with Food	Percent with Food
Oregon Inlet, N.C.	1965	8	3	37.50
Hatteras, N.C.	1965	44	16	36.36
Oregon Inlet, N.C.	1966	29	17	58.62
Hatteras, N.C.	1966	34	11	32.35
Oregon Inlet, N.C.	1967	4	1	25.00
Hatteras, N.C.	1967	71	31	43.66
Oregon Inlet, N.C.	1968	63	38	60.32
Hatteras, N.C.	1968	42	14	33.33
Bimini	1969	23	7	30.43
Oregon Inlet, N.C.	1969	45	25	55.55
Hatteras, N.C.	1969	74	46	62.16
Oregon Inlet, N.C.	1970	4	2	50.00
Hatteras, N.C.	1970	124	48	38.71
Hatteras, N.C.	1971	5	3	60.00
Hatteras, N.C.	1972	48	10	20.83
Oregon Inlet and Hatteras, N.C.	1980–1981	71	49	69.01
Cape Lookout, N.C.	1980–1981	44	35	79.54
Cape Fear, S.C.	1980–1981	31	26	83.87
Georgia	1981	6	2	33.33
East coast Florida	1980	13	5	38.46
South Florida (Keys)	1980–1981	7	6	85.71
Northwest Florida	1980–1981	74	56	75.68
Mississippi Delta	1980	7	5	71.43
Northeast Texas	1980	2	1	50.00
South Texas	1980	12	9	75.00
Total		885	466	52.65

In volume, fish also dominated, comprising 94.3% of all stomach contents collected in 1980 and 1981 (Table 3). The 194 wahoo sampled in those years yielded 11,260 ml of food or 58 ml per fish. Volume was converted to weight by the equation: $W = -1.3636 + 1.0844(V)$; $N = 25$, $r = 0.99$, where W = weight of food in grams and V = volume of food in millimeters. Thus total food weight was 12,209 g or 61.5 g per stomach. Weights for specific food items may be calculated by the same equation. Major foods by percent volume were scombrids (46.9%), unidentifiable fish remains (19.8%), and exocoetids (15%). Other foods were of minor importance.

Stomach contents of 71 fish collected in 1980 and 1981 from the Gulf of Mexico are presented in Table 4. The overall diet for wahoo in the Gulf of Mexico was generically similar to that in the southeastern Atlantic. Fish was the primary food, and the same kind of fish generally was consumed. Differences in the diets were Spanish sardine, *Sardinella aurita,* round scad, *Decapterus punctatus,* dolphin, *Corypheana hippurus,* an unidentified echeneid, and gray triggerfish, *Balistes capriscus.* These were found only in wahoo stomachs from the Gulf of Mexico.

There was no relationship between predator size and the size of the prey ($r = 0.41$) probably because wahoo bit many of the larger fishes into pieces. Thirty-two intact forage fish (average length 192.4 mm) were removed from the stomachs of 32 wahoo (average length 1,186.5 mm). Whole forage fish averaged approximately 16% of wahoo length (range from 2 to 37%). The largest forage fish was a 457 mm little tunny, *Euthynnus alletteratus,* eaten by a 1,238 mm wahoo.

Table 2. Items found in wahoo stomachs collected from 1965–1981 along the southeastern United States, Gulf of Mexico, and Bimini

Items	Frequency of Occurrence (N = 466)	Percent Frequency	Number of Items (N = 984)	Percent by Number
Fish	444	95.3	905	92.0
Unidentified fish	123	26.4	168	17.1
Clupeidae	49	10.5	83	8.4
Etrumeus teres	44	9.4	78	7.9
Sardinella aurita	2	0.4	2	0.2
Unid. clupeid	3	0.6	3	0.3
Paralepidae	2	0.4	7	0.7
Macroparalepsis affine	2	0.4	7	0.7
Exocoetidae	53	11.4	64	6.5
Cypselurus melanurus	25	5.4	28	2.8
Cypselurus sp.	19	4.1	23	2.3
Hyporhamphus unifasciatus	2	0.4	5	0.5
Unid. exocoetid	7	1.5	8	0.8
Echeneidae	1	0.2	1	0.1
Unid. echeneid	1	0.2	1	0.1
Carangidae	25	5.4	45	4.6
Alectis ciliaris	2	0.4	2	0.2
Caranx sp.	1	0.2	1	0.1
Decapterus punctatus	5	1.1	6	0.6
Decapterus sp.	5	1.1	25	2.5
Selene setapinnis	1	0.2	2	0.2
Unid. carangid	5	1.1	9	0.9
Coryphaenidae	1	0.2	1	0.1
Coryphaena hippurus	1	0.2	1	0.1
Scombridae	168	36.1	226	23.0
Auxis thazard	106	22.7	143	14.5
Euthynnus alletteratus	4	0.9	5	0.5
Euthynnus pelamis	6	1.3	8	0.8
Sarda sarda	9	1.9	10	1.0
Scomberomorus cavalla	8	1.7	12	1.2
Scomberomorus regalis	1	0.2	1	0.1
Thunnus atlanticus	2	0.4	2	0.2
Thunnus thynnus	1	0.2	3	0.3
Unid. scombrid	35	7.5	42	4.3
Stromateidae	11	2.4	162	16.5
Peprilus alepidotus	1	0.2	1	0.1
Peprilus triacanthus	9	1.9	155	15.7
Peprilus sp.	1	0.2	6	0.6
Dactylopteridae	1	0.2	1	0.1
Dactylopterus volitans	1	0.2	1	0.1
Bothidae	1	0.2	1	0.1
Unid. bothid	1	0.2	1	0.1
Balistidae	14	3.0	22	2.2
Aluterus schoepfi	9	1.9	14	1.4
Aluterus sp.	1	0.2	1	0.1
Unid. filefish	1	0.2	2	0.2
Balistes capriscus	2	0.4	2	0.2
Unid. balistid	2	0.4	3	0.3
Diodontidae	73	15.7	124	12.6
Chilomycterus sp.	2	0.4	2	0.2
Diodon hystrix	70	15.0	121	12.3
Unid. diodontid	1	0.2	1	0.1
Cephalopoda	51	10.9	78	7.9
Loligo sp.	46	9.9	71	7.2
Argonauta sp.	3	0.6	4	0.4
Unid. cephalopods	3	0.6	3	0.3
Crustacea	1	0.2	1	0.1
Raninid megalopa	1	0.2	1	0.1
Sargassum	5	1.1	—	—
Eelgrass	1	0.2	—	—
Black plastic	1	0.2	—	—
Unid. food	6	1.3	—	—
Totals	466		984	

Table 3. Items found in wahoo stomachs collected in 1980 and 1981 along the southeastern United States and Gulf of Mexico

Item	Frequency of Occurrence (N = 194)	Percent Frequency	Number of Items (N = 331)	Percent by Number	Volume (11,260 ml)	Percent by Volume
Fish	176	90.7	269	81.3	10,618.0	94.3
Unid. fish	100	51.5	145	43.8	2,230.9	19.8
Clupidae	4	2.1	4	1.2	125.0	1.1
Sardinella aurita	2	1.0	2	0.6	85.0	0.7
Unid. clupeid	2	1.0	2	0.6	40.0	0.4
Exocoetidae	26	13.4	31	9.4	1,687.0	15.0
Cypselurus sp.	19	9.8	23	7.0	1,461.0	13.0
Unid. exocoetid	7	3.6	8	2.4	226.0	2.0
Echeneidae	1	0.5	1	0.3	15.0	0.1
Unid. echeneid	1	0.5	1	0.3	15.0	0.1
Carangidae	11	5.7	16	4.8	572.5	5.1
Decapterus punctatus	5	2.6	6	1.8	149.5	1.3
Caranx sp.	1	0.5	1	0.3	275.0	2.4
Unid. carangid	5	2.6	9	2.7	148.0	1.3
Coryphaenidae	1	0.5	1	0.3	185.0	1.6
Coryphaena hippurus	1	0.5	1	0.3	185.0	1.6
Scombridae	40	20.6	48	14.5	5,284.0	46.9
Auxis sp.	1	0.5	1	0.3	140.0	1.2
Euthynnus alletteratus	4	2.1	5	1.5	675.0	6.0
Unid. scombrid	35	18.0	42	12.7	4,469.0	39.7
Stromateidae	1	0.5	6	1.8	130.0	1.1
Peprilus sp.	1	0.5	6	1.8	130.0	1.1
Bothidae	1	0.5	1	0.3	10.0	0.1
Unid. bothid	1	0.5	1	0.3	10.0	0.1
Balistidae	5	2.6	8	2.4	150.1	1.3
Aluterus sp.	1	0.5	1	0.3	70.0	0.6
Unid. filefish	1	0.5	2	0.6	3.0	Tr
Balistes capriscus	2	1.0	2	0.6	6.8	0.1
Unid. balistid	2	1.0	3	0.9	70.3	0.6
Diodontidae	7	3.6	8	2.4	228.5	2.0
Diodon hystrix	4	2.1	5	1.5	43.5	0.4
Chilomycterus sp.	2	1.0	2	0.6	184.0	1.6
Unid. diodontid	1	0.5	1	0.3	1.0	Tr
Cephalopoda	41	21.1	61	18.4	625.0	5.5
Loligo sp.	37	19.1	55	16.6	542.0	4.8
Argonauta sp.	2	1.0	3	0.9	78.0	0.7
Unid. cephalopod	3	1.5	3	0.9	5.0	Tr
Crustacea	1	0.5	1	0.3	Tr	Tr
Raninid megalopa	1	0.5	1	0.3	Tr	Tr
Sargassum	4	2.1	—	—	7.5	0.1
Eelgrass	1	0.5	—	—	1.0	Tr
Black plastic	1	0.5	—	—	2.0	Tr
Unid. food	6	3.1	—	—	6.5	0.1

Parasites

Giant digenetic trematodes were found in many of the stomachs. The worms were never attached to the lining of the stomach and were generally located at the posterior end. These large Formalin-preserved trematodes measured 25 to 40 mm in length and 12 to 23 mm in width. They had subterminal suckers and very pronounced dermal rugae. Effects of preserving giant trematodes have been described by Nigrelli and Stunkard (1947) who argue that disfiguration of the animals by chemical fixatives has resulted in taxonomic errors. With the assistance of Dr.

Table 4. Stomach contents of wahoo collected in the Gulf of Mexico, 1980 and 1981

Item	Frequency of Occurrence (N = 71)	Percent Frequency	Number of Items (N = 141)	Percent by Number	Volume (3,717 ml)	Percent by Volume
Fish	65	91.5	130	92.2	3,688.9	99.2
Unid. fish	42	59.1	74	52.5	731.8	19.7
Clupeidae	2	2.8	2	1.4	85.0	2.3
Sardinella aurita	2	2.8	2	1.4	85.0	2.3
Echeneidae	1	1.4	1	0.7	15.0	0.4
Unid. echeneid	1	1.4	1	0.7	15.0	0.4
Carangidae	11	15.5	16	11.3	572.5	15.4
Decapterus punctatus	5	7.0	6	4.2	149.5	4.0
Caranx sp.	1	1.4	1	0.7	275.0	7.4
Unid. carangid	5	15.5	9	6.4	148.0	4.0
Coryphaenidae	1	1.4	1	0.7	185.0	5.0
Coryphaena hippurus	1	1.4	1	0.7	185.0	5.0
Scombridae	16	22.5	21	14.9	1,920.0	51.6
Euthynnus alletteratus	1	1.4	1	0.7	285.0	7.7
Unid. scombrid	15	21.1	20	14.2	1,635.0	43.9
Stromateidae	1	1.4	6	4.2	130.0	3.5
Peprilus sp.	1	1.4	6	4.2	130.0	3.5
Balistidae	3	4.2	4	2.8	7.1	0.2
Balistes capriscus	2	2.8	2	1.4	6.8	0.2
Unid. balistid	1	1.4	2	1.4	0.3	Tr
Diodontidae	4	5.6	5	3.5	42.5	1.1
Diodon hystrix	3	4.2	4	2.8	41.5	1.1
Unid. diodontid	1	1.4	1	0.7	1.0	Tr
Cephalopoda	10	14.1	11	7.8	19.1	0.5
Loligo sp.	10	14.1	11	7.8	19.1	0.5
Sargassum	1	1.4	—	—	4.0	Tr
Unid. food	4	5.6	—	—	5.0	Tr

Robin M. Overstreet[2] we have tentatively identified the parasites as *Hirudinella ventricosa*.

H. ventricosa were found in 712 of the 885 stomachs (80.5%) (Table 5) and averaged 2.1 per stomach that contained parasites. The number of worms per stomach ranged from 1 to 13. Most stomachs (68.4%) had only two, and only 16.9% and 11.2% had one and three, respectively (Table 6).

Using 1980 and 1981 data, we also examined association of parasites by size and sex of the host and by geographical collection site (Table 7). Infestation was calculated as the percent of fish that contained at least one trematode and as the mean number of parasites occurring in both parasitized and nonparasitized fish. Collectively, 71.4% of the males and 82.0% of the females were parasitized (Table 7). Males averaged 1.4 parasites, females 1.6. Lengths of male and female wahoo were similar: 1,164 mm for males, 1,200 for females. Parasitic infection appeared to be associated more with geographical area than with fish size or sex.

To evaluate possible effects of fish length, sex, or collection site on the number of trematodes occurring in the stomachs, we conducted analysis of variance tests for unbalanced sample sizes. Fork length and sex had no significant effect, $F_{246,1} = 0.26$ (n. sign. at 0.05) and $F_{239,1} = 0.07$ (n. sign. at 0.05), respectively, but geographic area did ($F_{239,9} = 7.78$, sign. at 0.05). Since the means seemed to be

[2] Robin M. Overstreet, Gulf Coast Research Laboratory, Parasitology Section, Ocean Spring, Mississippi 39564, personal communication, February 1982.

Table 5. Percent of wahoo stomachs with digenetic trematodes and average number of trematodes per parasitized stomach

Year(s)	Number of Stomachs Examined	Number of Stomachs with Trematodes	Percent	Number of Trematodes	Number of Trematodes/ Stomach with Parasites
1965–1972	618	501	81.06	1,047	2.09
1980	183	136	74.32	268	1.97
1981	84	75	89.29	142	1.89
Total	885	712	80.45	1,457	2.05

clumped into several groups (areas), we did a Duncan's (1975) multiple range test to determine area alignment. Infestation in samples from Cape Lookout, the east coast of Florida, South Florida, and the Mississippi Delta were least similar to infections in other areas. Wahoo caught off Cape Lookout had a significantly higher level and those from other areas a significantly lower level of infection. Overall, three groupings were evident from the test: Oregon Inlet and Cape Lookout; northwest Florida, South Carolina, Georgia, northeast Texas, and the Mississippi delta; and South Texas, South Florida, and the east coast of Florida.

The effects of this parasite on its host are unknown. However, we observed no apparent differences in fish growth or condition of the gonads between wahoo that had trematodes and those that did not.

A monostome, tentatively identified as *Didymocystis coastesi,* was occasionally found in the eye muscles of fish collected at Oregon Inlet, Hatteras, and Bimini.

Discussion

Stomach Contents

The most comprehensive study to date on the feeding habits of wahoo was conducted by Iversen and Yoshida (1957) on fish collected near the Line Islands in the Pacific Ocean. The study was based on the analyses of 235 stomachs (120 with food) obtained during March and November–December. These scientists also reported that pelagic fish were the dominant foods of wahoo. Major foods identified (frequency of occurrence) were mackerel scad, *Decapterus pinnulatus,* 50%; skipjack tuna, *Euthynnus pelamis,* 17.9%; squid, *Loligo* sp., 16.1%; puffer, Tetradontidae, 7.1%; pomfret, Bramidae, 3.6%; and flyingfish, *Cypselurus* sp., 1.8%. Small items were conspicuously absent from the diet. We also found only

Table 6. Frequency of the number of trematodes per parasitized wahoo stomach

Number of Trematodes/Stomach	Number of Stomachs	Percent
1	120	16.85
2	487	68.40
3	80	11.24
4	18	2.53
5	2	0.28
6	3	0.42
7	1	0.14
13	1	0.14
Total	712	100.00

Table 7. Giant trematode infection of wahoo collected in 1980 and 1981 by geographical area and sex of the host

Area	Males	Females	Total
Oregon Inlet, N.C.			
Number of wahoo	19	50	69
Mean length, FL mm (range)	1,161 (938–1,479)	1,191 (966–1,510)	1,183
Percent infestation	84.21	92.00	89.85
Mean numbers of parasites/fish (range)	1.74 (0–4)	1.78 (0–5)	1.77
Cape Lookout, N.C.			
Number of wahoo	16	23	39
Mean length, FL mm (range)	1,132 (950–1,483)	1,191 (995–1,790)	1,167
Percent infestation	93.75	95.65	94.87
Mean numbers of parasites/fish (range)	2.06 (0–3)	2.09 (0–4)	2.08
South Carolina			
Number of wahoo	12	18	30
Mean length, FL mm (range)	1,005 (870–1,300)	1,144 (680–1,698)	1,092
Percent infestation	83.33	77.78	80.00
Mean number of parasites/fish (range)	1.58 (0–3)	1.33 (0–3)	1.43
Georgia			
Number of wahoo	4	2	6
Mean length, FL mm (range)	1,184 (1,012–1,325)	1,025 (998–1,052)	1,131
Percent infestation	100.00	100.00	100.00
Mean number of parasites/fish (range)	1.25 (1–2)	1.50 (1–2)	1.33
East coast, Florida			
Number of wahoo	8	5	13
Mean length, FL mm (range)	1,244 (954–1,498)	1,183 (740–1,549)	1,214
Percent infestation	0.00	0.00	0.00
Mean number of parasites/fish (range)	0.00	0.00	0.00
South Florida (Keys)			
Number of wahoo	–	7	7
Mean length, FL mm (range)	–	1,123 (985–1,315)	1,123
Percent infestation	–	57.14	57.14
Mean number of parasites/fish (range)	–	0.86	0.86
Northwest Florida			
Number of wahoo	7	67	74
Mean length, FL mm (range)	1,369 (1,295–1,408)	1,248 (962–1,695)	1,259
Percent infestation	28.57	82.09	77.03
Mean number of parasites/fish (range)	0.57 (0–2)	1.61 (0–3)	1.51
Mississippi Delta			
Number of wahoo	1	6	7
Mean length, FL mm (range)	1,231	1,269 (1,050–1,510)	1,264
Percent infestation	0.00	83.33	71.43
Mean number of parasites/fish (range)	0.00	1.17 (0–2)	1.00
Northeast Texas			
Number of wahoo	1	1	2
Mean length, FL mm (range)	1,430	965	1,198
Percent infestation	100.00	0.00	50.00
Mean number of parasites/fish (range)	2.00	0.00	1.00
South Texas			
Number of wahoo	2	10	12
Mean length, FL mm (range)	1,105 (960–1,250)	1,119 (960–1,390)	1,117
Percent infestation	100.00	70.00	75.00
Mean number of parasites/fish (range)	2.00	1.20	1.33
All areas			
Number of wahoo	70	189	259
Mean length, FL mm (range)	1,164 (870–1,498)	1,200 (680–1,790)	1,191
Percent infestation	71.43	82.01	79.15
Mean number of parasites/fish (range)	1.43 (0–4)	1.57 (0–5)	1.49

Table 8. Selected food categories of scombrid and coryphaenid fishes collected along the southeastern United States and Gulf coasts, 1980 and 1981, expressed as percent frequency of occurrence

Species	Number with Food	Fish	Juvenile Fish	Invertebrates	Larval Crustaceans	Floating Materials
Wahoo	194	90.7	2.6	22.2	0.5	6.2
Dolphin[3]	1,358	88.1	26.2	29.3	9.1	48.0
Little tunny[3]	1,016	84.4	18.7	32.0	8.8	2.5
Blackfin tuna[3]	89	68.5	13.5	82.0	55.1	15.7
Yellowfin tuna[3]	186	76.3	17.2	84.9	45.7	30.6

one small food item, a crab megalopa, and it could have been regurgitated from a fish eaten by the wahoo. Data from other studies suggest that the diet of wahoo is similar with respect to the ecological groupings of foods throughout its range. Tester and Nakamura (1957) identified a carangid and other fish remains in wahoo sampled off Oahu, Hawaii. Calamaries (squid) and pelagic fish have been reported in wahoo collected off Japan and the Hawaiian Islands, respectively (Kishinouye, 1923; Welsh, 1949; cited in Iversen and Yoshida, 1957).

The apparent preference by wahoo for relatively large near-surface foods, such as epipelagic fish and squid, was evaluated by comparing the diet of wahoo with that of sympatric species. Food data[3] of dolphin, *Coryphaena hippurus,* little tunny, *Euthynnus alletteratus,* blackfin tuna, *Thunnus atlanticus,* and yellowfin tuna, *Thunnus albacares,* from the southeastern and Gulf coasts of the United States, tabulated by the senior author, were compared to foods of wahoo. The following food categories were compared: fish, invertebrates, floating materials such as *Sargassum,* other aquatic vegetation, plastics (indicating surface feeding), and very small food, such as immature stages of crustaceans, suggesting that the predator had strained or picked the items from the water column (Table 8). Wahoo, dolphin, and little tunny were similar in respect to the overall percentages of fish and invertebrates in their diet, but there was a distinct difference in the types of animals the three predators consumed. Dolphin fed primarily on juvenile fish and adult crabs and shrimps that are a part of the *Sargassum* community; little tunny fed extensively on adult clupeids, carangids, and stomatopods that are found inshore; and wahoo ate squids, scombrids, and clupeids that inhabit offshore waters. Blackfin and yellowfin tunas formed a separate group, one that utilized a much higher percentage of larval crustaceans and less fish.

The absence of small items in the diet of wahoo is probably attributable to the lack of gill rakers. Magnuson and Heitz (1971) found that volumes of crustaceans in the stomach contents of predatory fish in the Pacific were inversely related to the mean gill raker gap. Skipjack tuna had the smallest gap between gill rakers and the largest volume of crustaceans; wahoo had no gill rakers, thus the largest gap, and no crustaceans. In our study, the comparative volumes of ocean-floating material in the stomachs suggest that dolphin and blackfin and yellowfin tunas feed more frequently at the surface than do wahoo and little tunny (Table 8). The relatively low volume of floating materials for little tunny is misleading because this species is generally distributed shoreward of floating masses of *Sargassum* and associated materials. And since most of the floating materials as well as juvenile fish were small, the lack of gill rakers in wahoo could have resulted in the relatively low percentage of items that we believe suggest surface feeding.

[3] Unpublished data, National Marine Fisheries Service, Southeast Fisheries Center, Beaufort Laboratory, Beaufort, North Carolina 28516-9722.

Wahoo may indeed feed more readily at the surface than our comparison indicates. But, we do not think so.

In summary, the wahoo is a pelagic carnivore that feeds on a variety of pelagic fishes as well as squids. Unlike dolphin and tunas, it does not usually eat small food items, nor does it feed as readily at the surface. Based on our observations and analyses there is no apparent relationship between the size of the wahoo and the size of its prey, possibly because the wahoo is able to render even large fish into consumable-size portions with its sharp teeth.

Parasites

With few exceptions the Digenea are endoparasites of marine, fresh water, and terrestrial vertebrates. They have complicated life cycles involving an alternation of generations and hosts. Adults generally occur in the digestive tract, particularly the stomach, and move little during this stage of their lives, remaining near the site of attachment. A group of Digenea, the giant trematodes of the genus *Hirudinella,* frequently parasitize scombrid fishes (Nigrelli and Stunkard, 1947; Nakamura and Yuen, 1961; Yamaguti, 1970). And there have been numerous reports of trematodes infecting wahoo collected in both the Atlantic and Pacific Oceans. Iversen and Yoshida (1957) identified *H. ventricosa* in 98% of the wahoo sampled from waters off the Line Islands. Two parasites per fish were most often encountered, which the scientists believed suggested a physiological equilibrium between the host and the parasite. Iversen and Hoven (1958) included *H. marina* and *H. ventricosa,* found in wahoo, in a description of trematodes of fishes from the Central Equatorial Pacific and also referred to papers (that we have not seen) by Kishinouye (1923) and Edmonson (1946) that commented, respectively, on large unidentified trematodes in *A. solanderi* from the Hawaiian Islands and from Japan.

Only one study that we are aware of (Nakamura and Yuen, 1961) attempts to evaluate the incidence of parasitism by giant trematodes by size and sex of the host and by geographical area of collection. The host was skipjack tuna and the parasite *H. marina.* They concluded that the significant difference in the occurrence of trematodes in tuna from Hawaii and tuna from off the Marquesas was possibly attributable to time (year of collection) rather than simply area. Nakamura and Yuen reported no significant size- or sex-related differences in parasitized and nonparasitized skipjack tuna. Since the data in the current study (Table 7) were collected over a short period, 1980–1981, time is probably not a contributing factor to the differences in levels of parasitic infection between areas. Although wahoo are highly migratory, the extent of their migrations is unknown. Our data show a distinct difference in levels of infestation between wahoo from the east coast of Florida–South Florida and wahoo from the rest of the southeastern Atlantic. This difference may indeed reflect two populations of wahoo along the southeastern U.S. coast: a northern population characterized by a high incidence of trematodes, and a southern population with a much lower incidence. By comparison, wahoo collected from different areas in the Gulf of Mexico had similar parasite fauna and were generally more characteristic of wahoo collected from the northern as opposed to the southern Atlantic area. The presumable cause in geographic differences is diet, e.g., ingestion of the intermediate host. However, the life cycle of *Hirudinella* spp. is unknown, and our data are inadequate to suggest possible transmittal mechanisms by area. The fact that we and Nakamura and Yuen found no relationship between parasitism and size or sex of host is understandable. Wahoo do not segregate by sex, and their size does not appear to be a factor in the size or type of prey selected.

Like most studies pertaining to parasites of fish, ours does not provide substantive information that may be used in the management of wild populations. Two important questions that have not been answered in the literature are: "What, if any, harm is done to the host?" "How is the parasite transmitted?" We speculate that like other digenetic trematodes, *H. ventricosa* attaches to the lining of the digestive tract. The place of attachment is probably lesioned by the physical abrasion and histolytic enzymes secreted by the worms as they feed on the host's blood, and ulceration ultimately occurs. However, we have not observed ulceration or scar tissue by our gross examination of the digestive tracts, and we have found no apparent difference in the condition of parasitized and nonparasitized wahoo. It is possible that *H. ventricosa,* when occurring with other internal parasites, could be detrimental to its host. It is our experience that fish possess a unique ability to not only survive, but to do well, even when their digestive tracts have been severely damaged by lacerations and punctures. Worms usually being contained within the viscera and therefore not visible reduce the problem of consumer rejection of parasitized fish.

The life cycle, and thus the transmittal mechanism, of *H. marina* and *H. ventricosa* are unknown. However, we believe that a study by Hunninen and Cable (1943) on another marine hemiurid trematode, *Lecithaster confusus,* may provide an insight into what the life history of *H. ventricosa* is like. The cercariae of *L. confusus* develop in the digestive gland of marine snails and are later released. The cercariae are then consumed by copepods where they develop into unencysted, active metacercariae. The adult worms have been found in several species of marine fish. It seems probable that *H. ventricosa* also have snails and copepods as intermediate hosts and a large piscivore, such as a wahoo, as the definitive host. There is presumably another intermediate link in the cycle, a fish, such as a clupeid or small scombrid.

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